

Transportation Air Quality and MOVES Training

Module 2: Introduction to MOVES

Note: This material is part of a five module training course prepared by the Texas A&M Transportation Institute (TTI) for the Texas Department of Transportation. Please review the training description document for further details and for TTI contact information

Objective

EPA On-road Models

Overview of MOVES2014a (MOVES) Model

MOVES Structure, Feature, Scales

Modeling Scales

Hands-on National Scale Exercise –Bexar County

Best Practices

EPA On-Road Models: Historical Perspective

| Models | Milestones | Observations |
|-------------------|---------------------|---|
| MOBILE6.2 | Sep 2003 – Dec 2012 | Fast Used engine certified standards |
| MOVES2010* | Mar 2010 – Dec 2012 | Real world (in-use) emissions data Increase in NO _x , PM _{2.5} , CO Slight decrease in VOC emissions, |
| MOVES2010a | Sep 2010 – Jan 2013 | Increase in methane Slight decrease in VOC and PM ₁₀ emissions |
| MOVES2010b | Jan 2013 – Oct 2016 | Added all Mobile Source Air Toxic (MSAT) pollutants |
| MOVES2014* | May 2014 – Dec 2015 | Tier-3 Rule Activity and emission rate update |
| MOVES2014a | Dec 2015– Current | Minor change in VOC, PM _{2.5} and CO ₂ |

*Conformity Grace Period

MOVES – MOtor Vehicle Emissions Simulator Overview

**EPA's
Emission
Estimation Model**

On-road vehicles

(cars, trucks, motorcycles,
and buses)

Rates for 60+ Items

Criteria pollutants

GHG

Air toxics

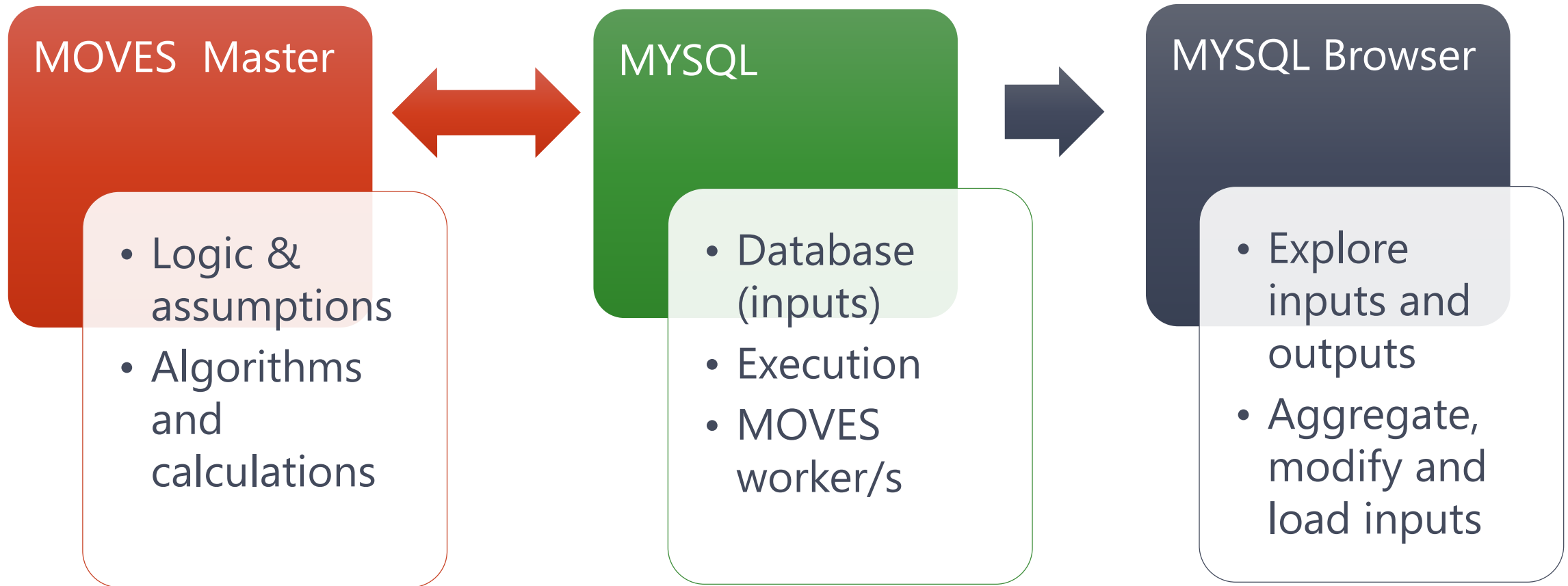
Energy consumption

Based on

- Emissions test results
- EPA's understanding of vehicle emissions

Uses multitude of databases and equations to generate rates

MOVES Structure



MOVES Features

Structure

- *Graphical User Interface (GUI)*
- *Database*
 - *Default or User Supplied Data*

Scale

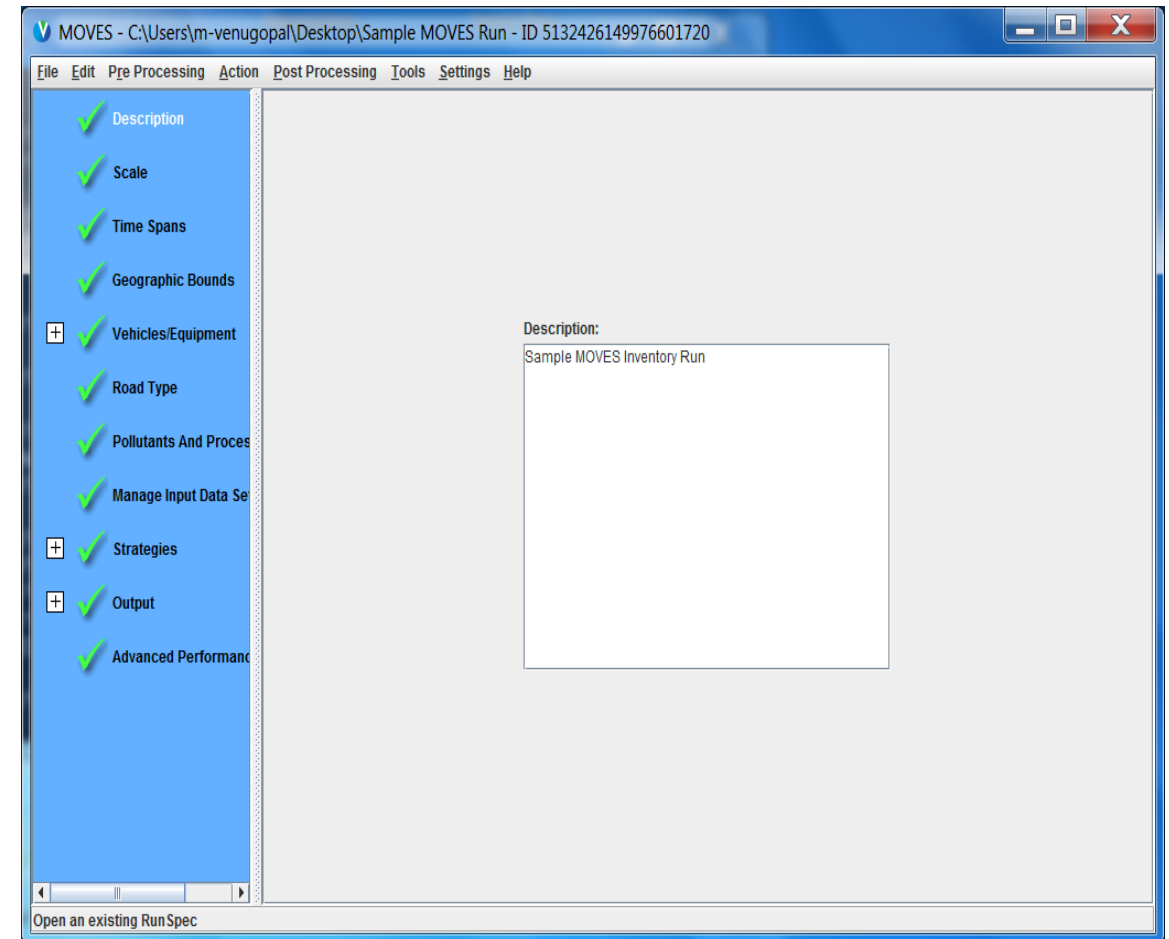
- *National, County, and Project*

Calculation Mode

- *Rate (mass/activity)*
- *Inventory (pounds, tons)*

Time Span

- *1990, 1999-2050*
- *Any or All Months of a Year*
- *Weekday and/or Weekend*
- *Any or All Hours of a Day*



MOVES Features Cont'd

Emission Processes

- *Running, Start, Extended Idle, Crankcase, Evaporative (Permeation, Vapor Venting, Liquid Leaks), Refueling (Vapor loss, Spillage), Crankcase, Tire Wear, Brake Wear*

Pollutants

- *HC Species, CO, NO_x, NH₃, SO₂, PM, CO₂, CH₄, N₂O, 50+ Toxics, Energy*

Fuels

- *Gasoline, CNG, Diesel, Ethanol (E-85), Electric*

Vehicle Type

- *Motorcycle, Passenger Car, Passenger Truck, Light Commercial Truck, Intercity Bus, Transit Bus, School Bus, Refuse Truck, Single Unit Short-haul Truck, Single Unit Long-haul Truck, Motor Home, Combination Short-haul Truck, Combination Long-haul Truck*

Roadway Type

- *On-network (Rural and Urban Restricted and Unrestricted Access)*
- *Off-network (Idling, starts, etc.)*

MOVES Modeling Scales

National

- *Uses Default Data*
- *Multiple States and Counties*
- *Both Rate and Inventory Calculations*
- *Not Recommended for Transportation Conformity and SIP*

County

- *User can Populate Local Data*
- *One County or Custom Domain*
- *Required for Transportation Conformity and SIP*
- *Both Rate and Inventory Calculations*

Project

- *Link level Modeling of Transportation Projects*
- *User can Populate Project Specific Data*
- *Required for Quantitative Hot-Spot Analysis*
- *Both Rate and Inventory Calculations*

MOVES Working Process Cont'd

Run Specification File (Runspec)

- Create Single Runspec and Modify Subsequent Ones
- Multiple Runspec Creator in MOVES Model

County Data Manager and Project Data Manager

- Can Bypass Using MSQL Queries

Running Model

- Running Multiple Runspecs in One Instance
- Using Multiple Computers for Single Run
- Invoking Multiple Workers on Same Computer

Output

- Customize Output Using MSQL Queries
- MOVES Model Post Processing Tools

MOVES Application

State Implementation Plan (SIP)

- *Attainment Demonstration SIP*
- *Reasonable Further Progress SIP*

Regional Transportation Conformity

Project Level Analysis

- *Mobile Source Air Toxics*
- *CO & PM Hotspot*

Alternative Scenarios

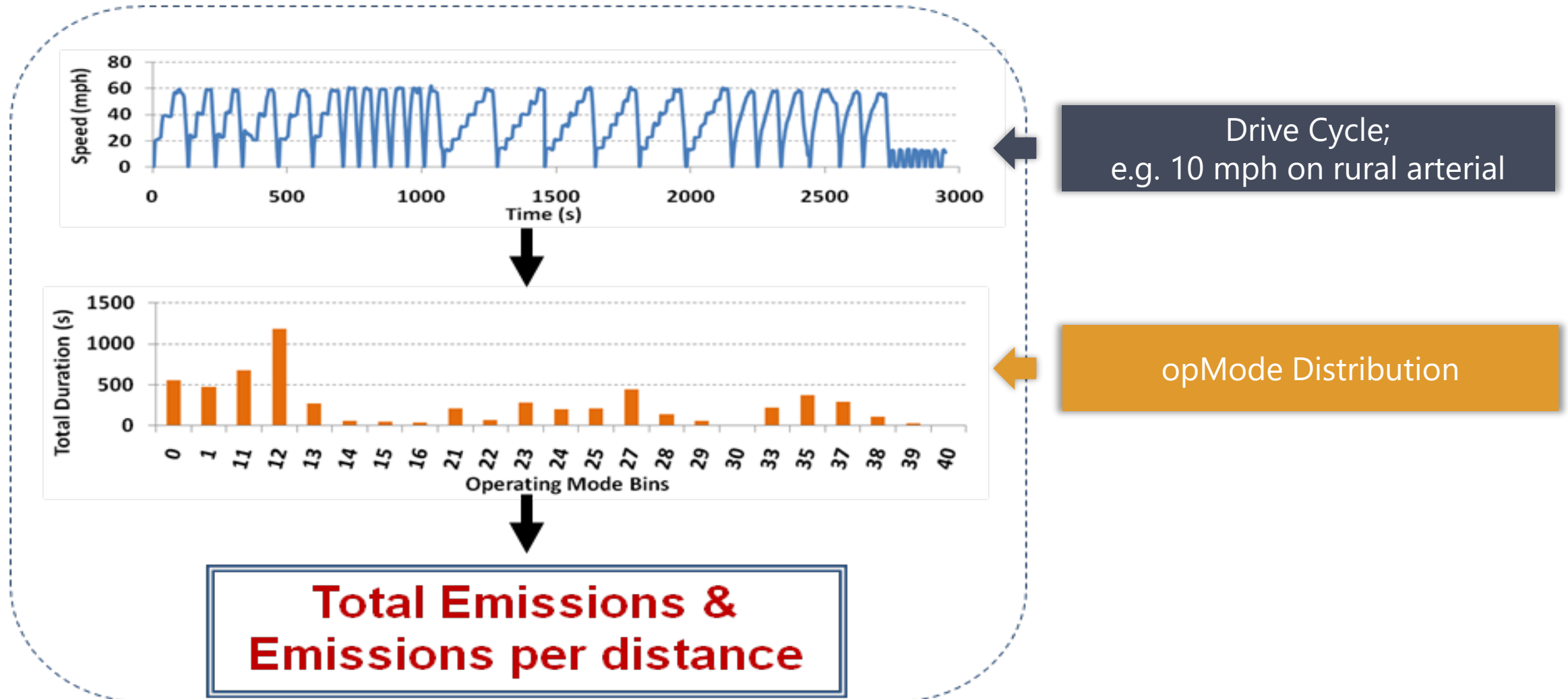
- *Mobility Plan Analysis*
- *What-if Scenarios*

Trend Analysis

Emission Reduction Measure Analysis

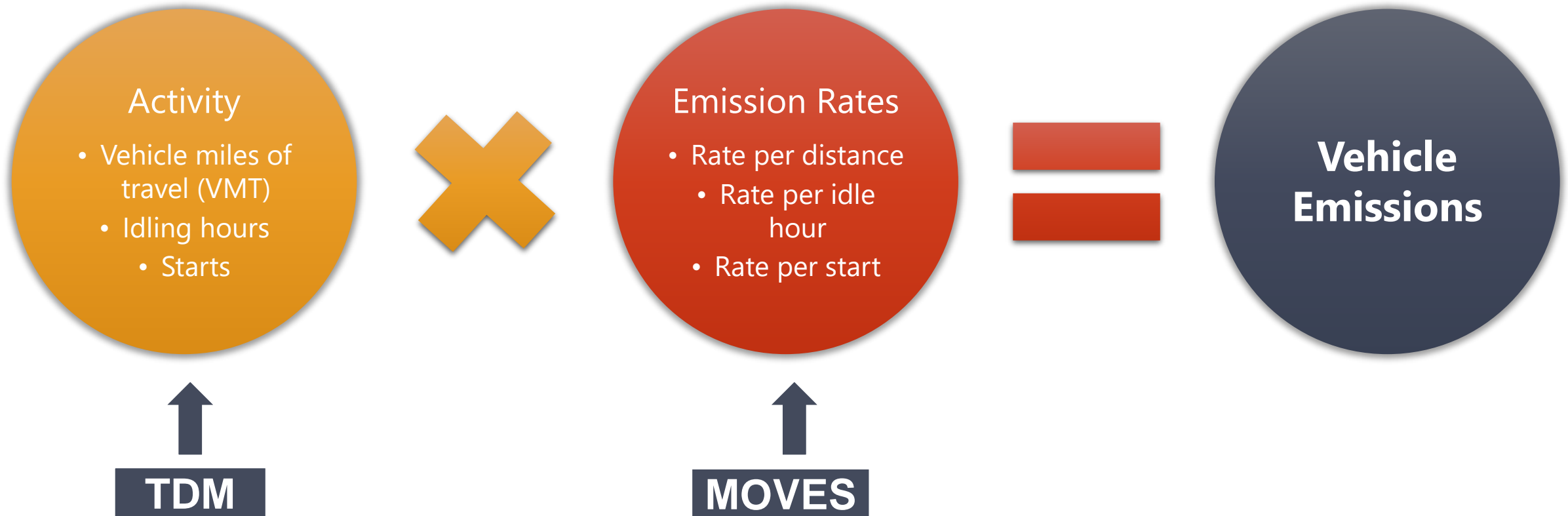
- *Congestion Mitigation and Air Quality Reporting*
- *Project Selection (Cost-Effectiveness)*

MOVES Emission Rates

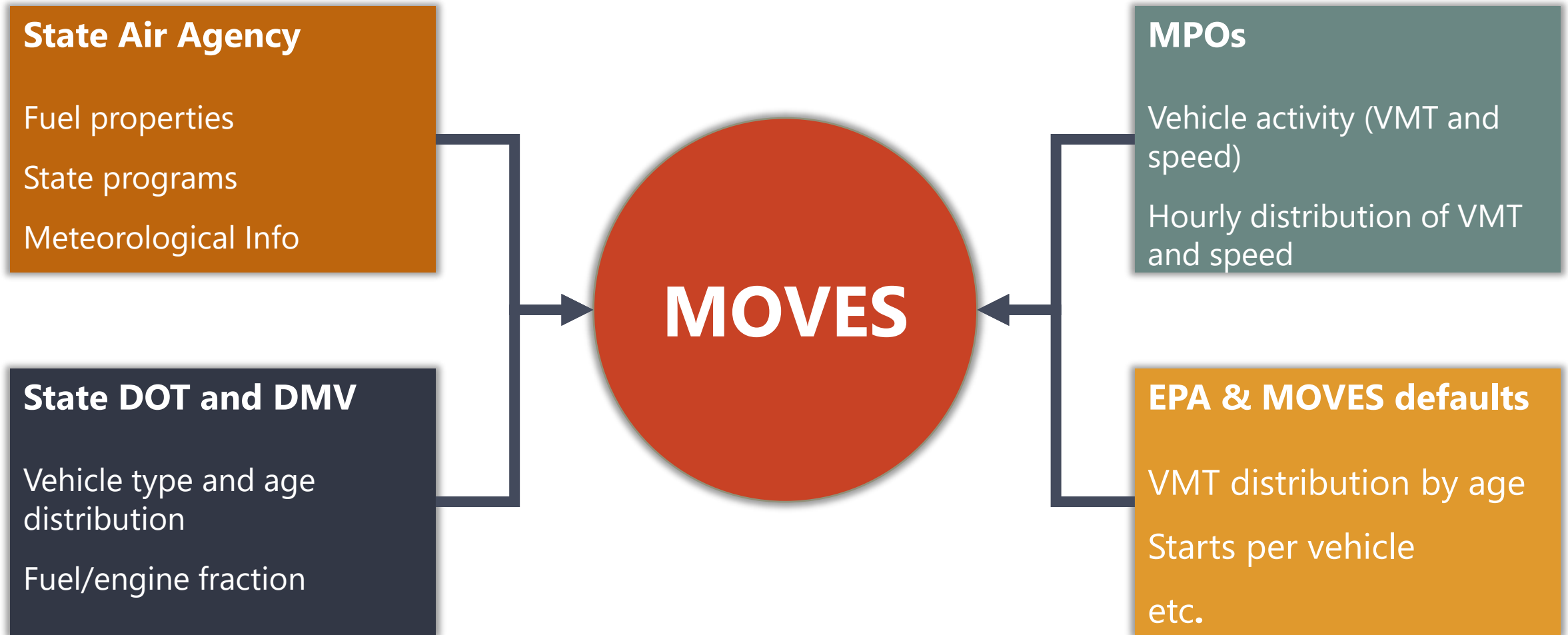


Reminder !!!!

- The key analytical component of the conformity determination



MOVES Key Inputs



MOVES Inputs- Sensitivity Analysis

| MOVES Input | VOC | NOx | PM |
|---------------------------------------|------------------|------------------|------------------|
| Temperature | Very Substantial | Very Substantial | Very Substantial |
| Humidity | Modest | Substantial | Modest |
| Speed | Very Substantial | Very Substantial | Very Substantial |
| Age | Very Substantial | Substantial | Substantial |
| VMT | Substantial | Very Substantial | Very Substantial |
| Population | Substantial | Substantial | Substantial |
| Ramp Fraction | Modest | Modest | Substantial |
| Source Type Detail for Road Type Dist | Modest | Modest | Moderate |
| Source Type Detail for Speed Dist | Modest | Modest | Moderate |
| Month VMT Fraction | Modest | Modest | Modest |
| Hour VMT Fraction | Modest | Modest | Modest |

Source: NCHRP 25-38

MOVES Inputs-Local Vs. Default

| Data Type | MOVES Input Tables | Rate Mode | Inventory Mode |
|------------------------|--|---------------|----------------|
| Speed Distribution | avgspeeddistribution | Default/Local | Local |
| Fuel | fuelformulation, fuelsupply, fuelusagefraction, AVFT | Local | Local |
| Hotelling | hotellingactivitydistribution hotellinghours | Optional | Optional |
| Vehicle Type VMT | hpmsvtypeyear, hourvmtfraction, dayvmtfraction, monthvmtfraction | Default/Local | Local |
| Road Type Distribution | roadtypedistribution | Default/Local | Local |
| IM Program | imcoverage | Local | Local |
| Starts | starts, startshourfraction startshouradjust, startspersday startssourcetypefraction, Importstartsupmodedistribution | Optional | Optional |
| Ramp Fraction | Roadtype | Local | Local |
| Age Distribution | sourcetypeagedistribution | Local | Local |
| Source Type Population | sourcetypeyear | Default/Local | Local |
| Meteorology Data | zonemonthhour | Local | Local |
| Retrofit Data | onroadretrofit | Optional | Optional |

Summary

Strengths

- **Wide-range of on-road vehicles**
- **Base on real-world emissions data**
- **Calculations at 1Hz-basis**
- **Project-level to national-level**
- **Can use local data**

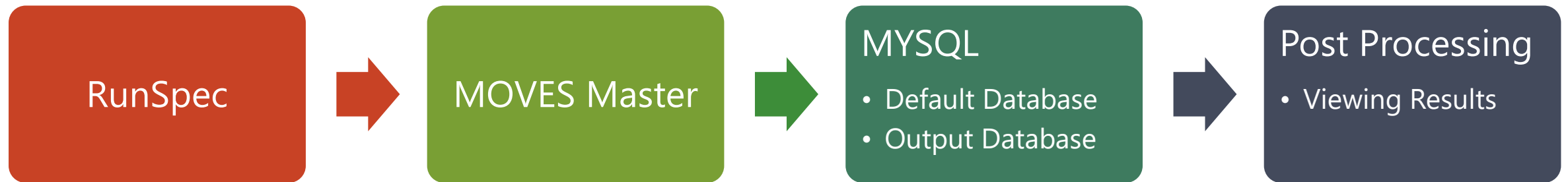
Weakness

- **Long runtime: resource-intensive**
- **Requires a lot of local data**
- **Future projections based on existing regulations**
- **Aggregated vehicle types and technologies**
- **Limited representation of alternative fuel vehicles**



Hands on Exercise MOVES Inventory Run

MOVES Modeling Model

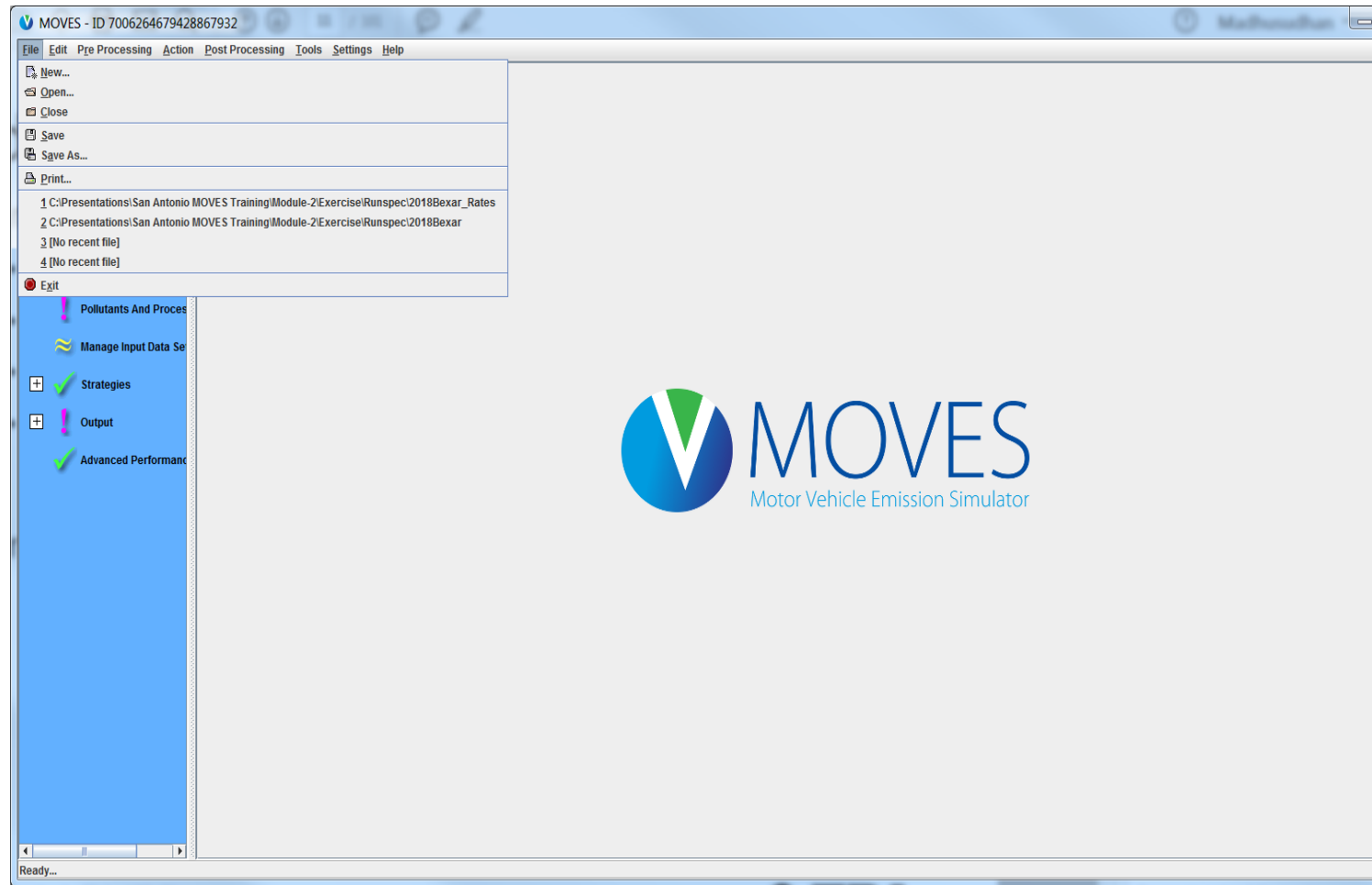


MOVES - GUI

Navigation Panel

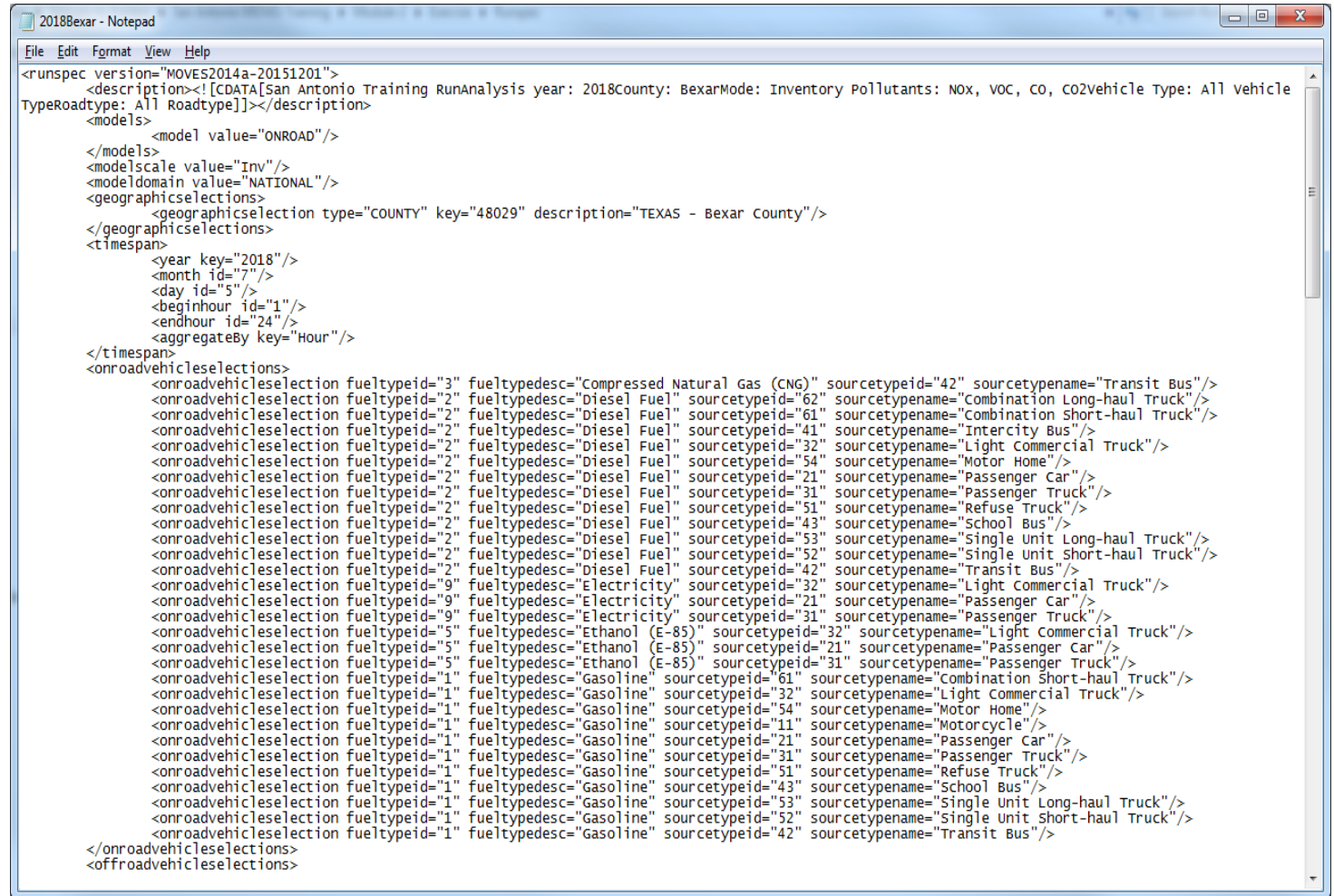
RunSpec (mrs)

Name:
"2020Bexar_Inv_Training.
mrs"



Understanding MOVES RunSpec

- Extensible Markup Language (XML) file
- Instructions telling
- What to model
- What database to use
- What is output preference
- Reloaded and run again or edited



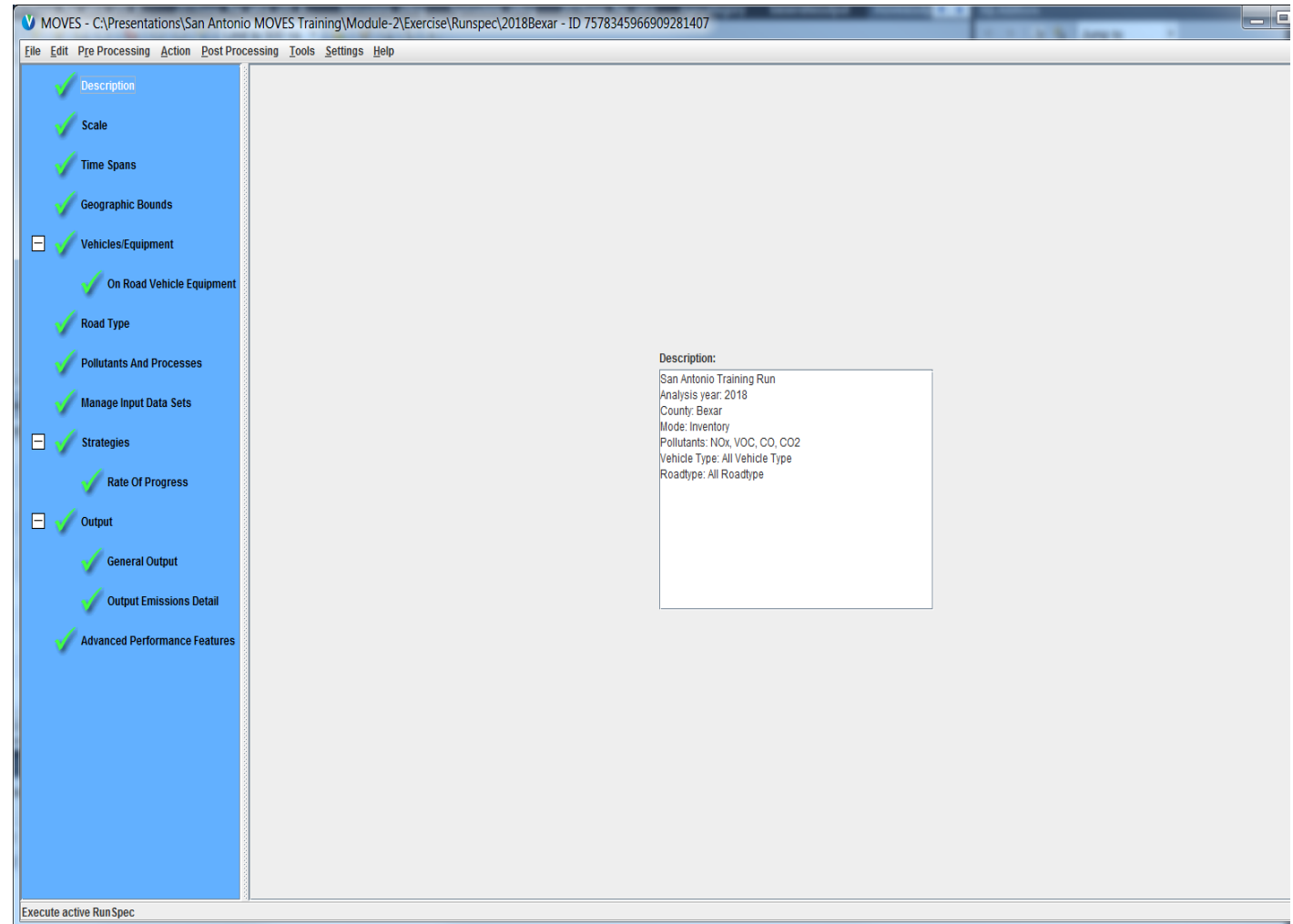
```
<runspec version="MOVES2014a-20151201">
  <description>![CDATA[San Antonio Training RunAnalysis year: 2018County: BexarMode: Inventory Pollutants: NOx, VOC, CO, CO2Vehicle Type: All vehicle TypeRoadtype: All Roadtype]]</description>
  <models>
    <model value="ONROAD"/>
  </models>
  <modelscale value="Inv"/>
  <modeldomain value="NATIONAL"/>
  <geographicselections>
    <geographicselection type="COUNTY" key="48029" description="TEXAS - Bexar County"/>
  </geographicselections>
  <timespan>
    <year key="2018"/>
    <month id="7"/>
    <day id="5"/>
    <beginhour id="1"/>
    <endhour id="24"/>
    <aggregateBy key="Hour"/>
  </timespan>
  <onroadvehicleselections>
    <onroadvehicleselection fueltypeid="3" fueltypedesc="Compressed Natural Gas (CNG)" sourceypeid="42" sourceypename="Transit Bus"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="62" sourceypename="Combination Long-haul Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="61" sourceypename="Combination Short-haul Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="41" sourceypename="Intercity Bus"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="32" sourceypename="Light Commercial Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="54" sourceypename="Motor Home"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="21" sourceypename="Passenger Car"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="31" sourceypename="Passenger Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="51" sourceypename="Refuse Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="43" sourceypename="School Bus"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="53" sourceypename="Single Unit Long-haul Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="52" sourceypename="Single Unit Short-haul Truck"/>
    <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourceypeid="42" sourceypename="Transit Bus"/>
    <onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourceypeid="32" sourceypename="Light Commercial Truck"/>
    <onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourceypeid="21" sourceypename="Passenger Car"/>
    <onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourceypeid="31" sourceypename="Passenger Truck"/>
    <onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourceypeid="32" sourceypename="Light Commercial Truck"/>
    <onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourceypeid="21" sourceypename="Passenger Car"/>
    <onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourceypeid="31" sourceypename="Passenger Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="61" sourceypename="Combination Short-haul Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="32" sourceypename="Light Commercial Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="54" sourceypename="Motor Home"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="11" sourceypename="Motorcycle"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="21" sourceypename="Passenger Car"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="31" sourceypename="Passenger Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="51" sourceypename="Refuse Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="43" sourceypename="School Bus"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="53" sourceypename="Single Unit Long-haul Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="52" sourceypename="Single Unit Short-haul Truck"/>
    <onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourceypeid="42" sourceypename="Transit Bus"/>
  </onroadvehicleselections>
</runspec>
```

MOVES - Description

Beneficial to include:

- Reason
- County
- Analysis year and month
- Pollutant(s)
- Other

Limit is 5,000 characters of text

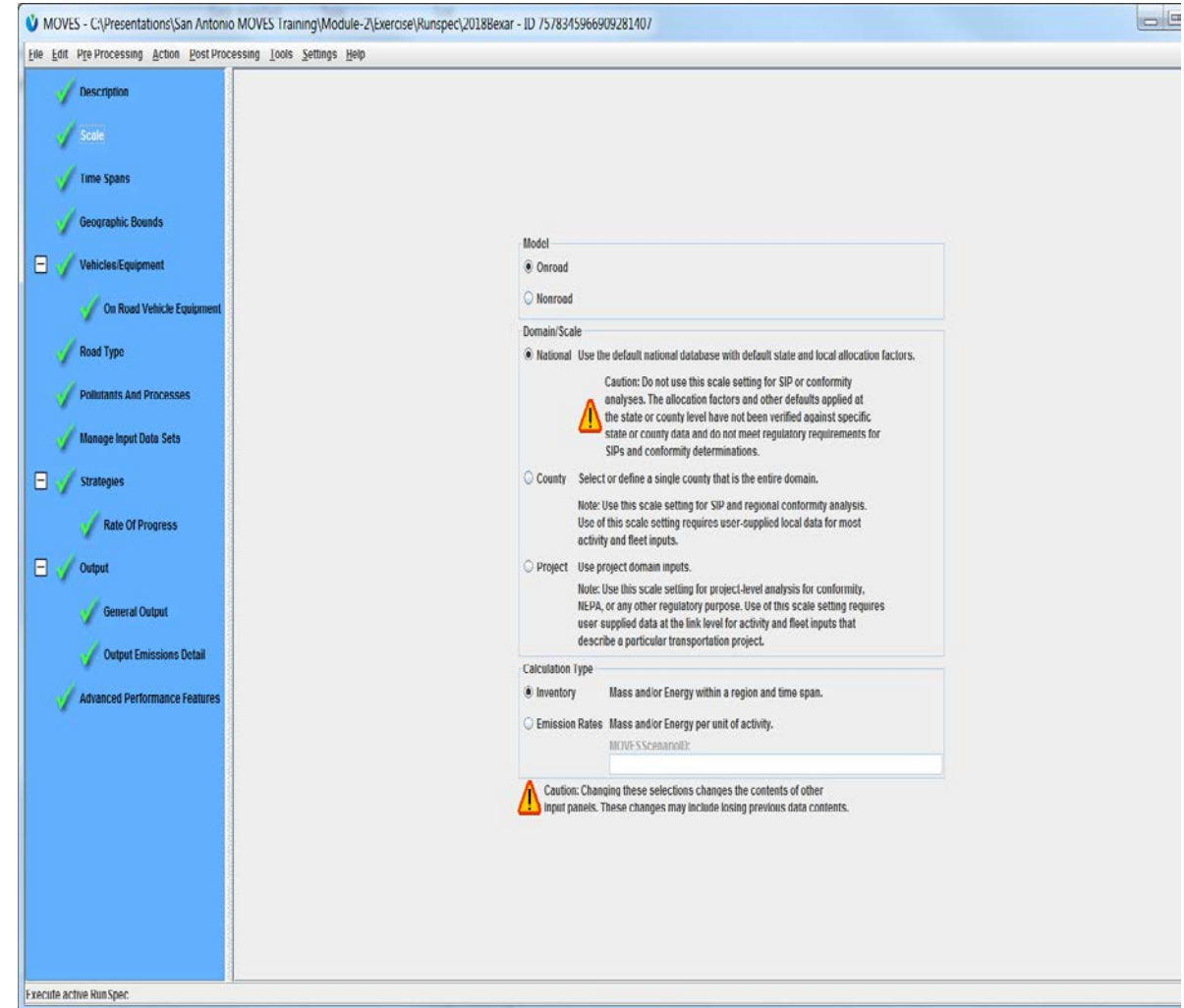


MOVES – Modeling Scales

For this exercise:

- Onroad run
- National scale
- Inventory mode

Note: National scale not recommended for conformity analysis



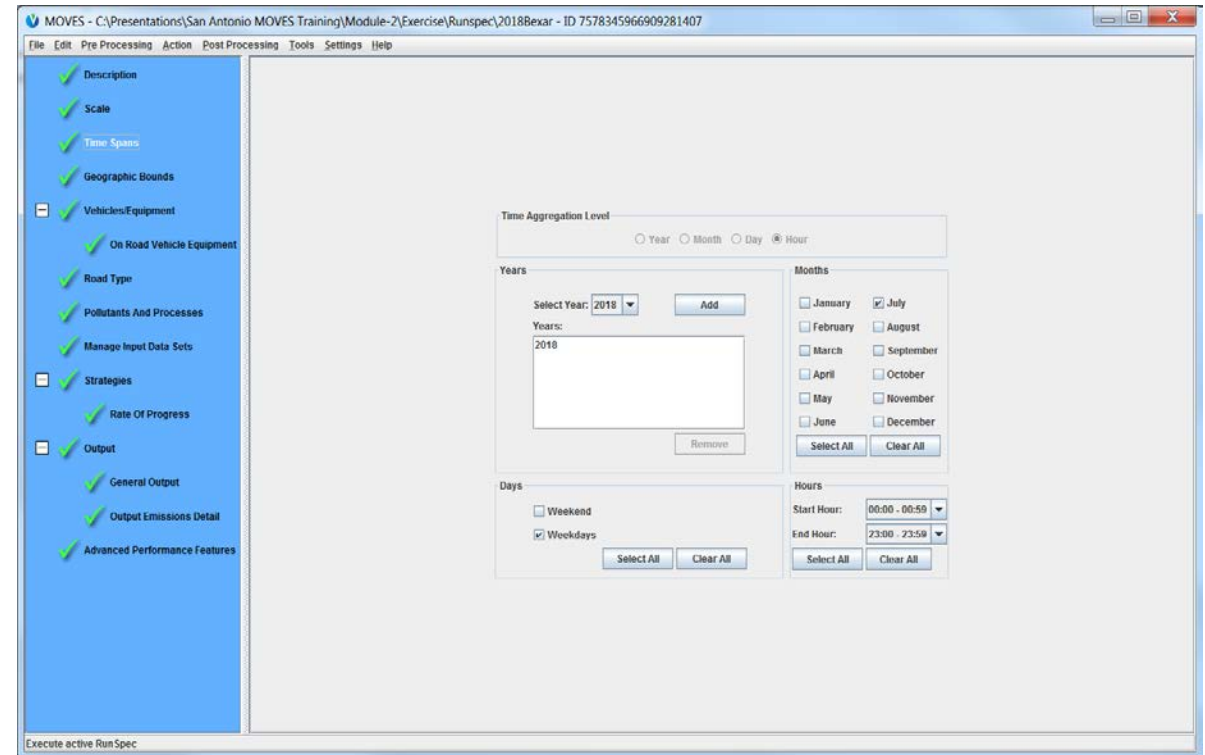
MOVES - Time Period

Selection for this exercise

- 2020
- Month July
- Weekday
- All hours

If you select HC pre-aggregation is selected to hour

Hourly information are recommended for regulatory applications



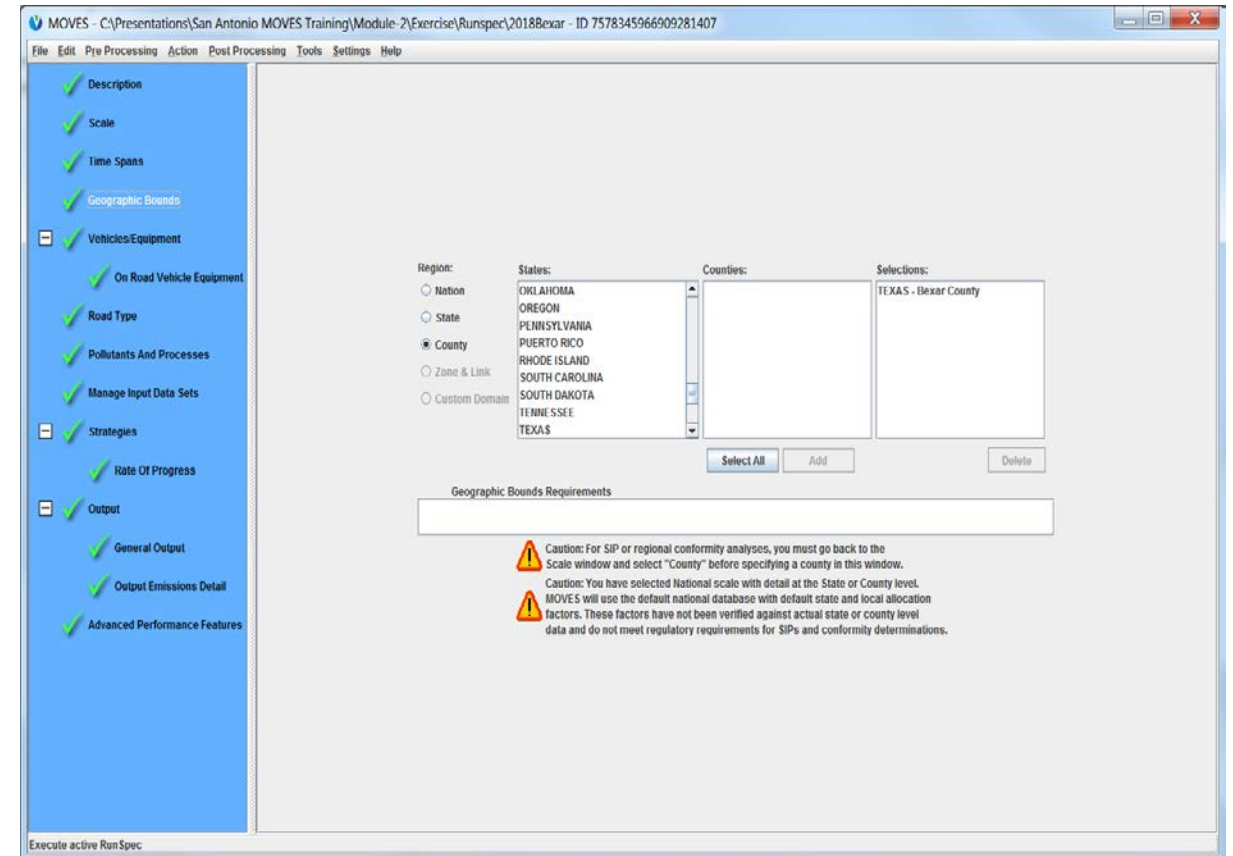
MOVES Geographic Area

Select

- Texas
- Bexar County

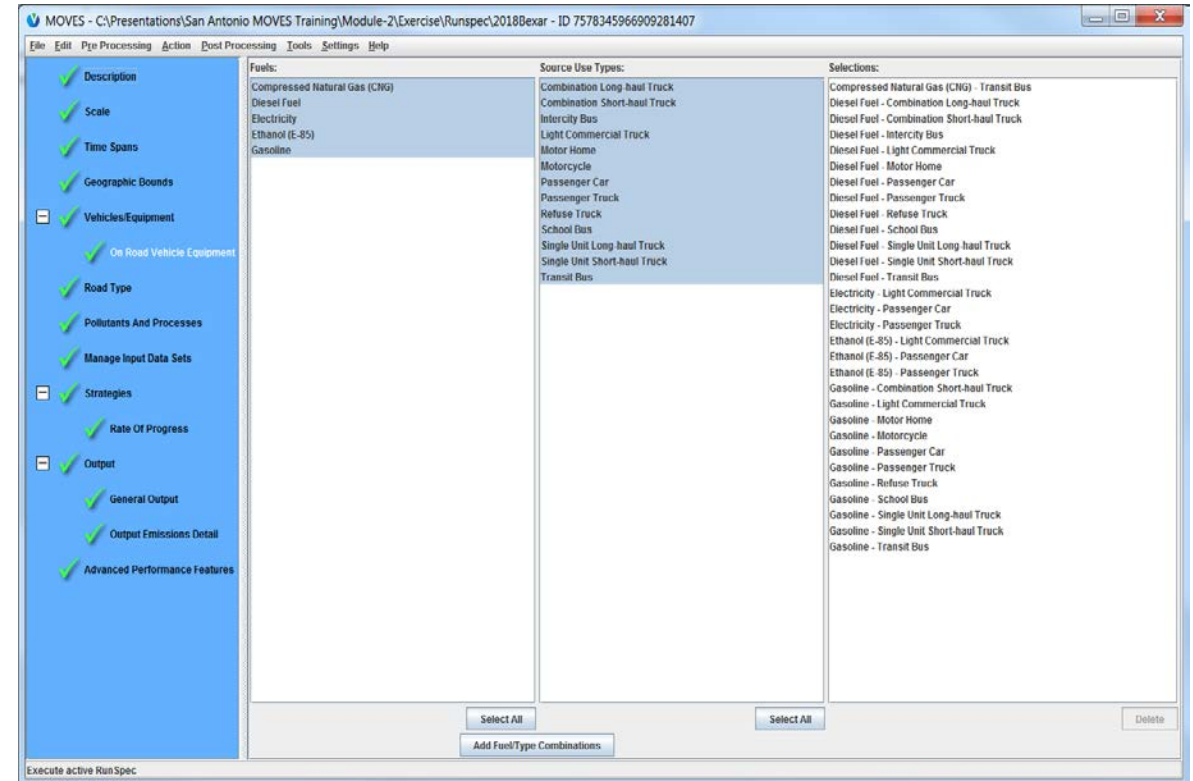
Can select multiple counties, outputs will be stored in same database

Nation, State, and County are available



MOVES- Vehicle types & Fuel

| Vehicle Class | Source Type ID | Description |
|---------------------|----------------|---|
| Light Duty | 11 | MotorCycle |
| | 21 | Passenger Car |
| | 31 | Passenger Truck: SUV, Pickup Truck, Minivans - Two-Axle/Four-Tire Single Unit |
| | 32 | Light Commercial Trucks - Two-Axle/Four-Tire Single Unit |
| Buses & Medium-Duty | 41 | Intercity Buses |
| | 42 | Transit Buses |
| | 43 | School Buses |
| | 52 | Single-Unit Short-Haul Trucks |
| | 53 | Single-Unit Long-Haul Trucks |
| | 54 | Single- Unit Motor Homes |
| Heavy Duty | 51 | Refuse Trucks |
| | 61 | Combination Short-Haul Trucks |
| | 62 | Combination Long-Haul Trucks |



**** Traditionally gasoline and diesel fuel used in the conformity analysis in Texas****

MOVES Roadtype

Select All Roadway Types

Rural & Urban Restricted Access

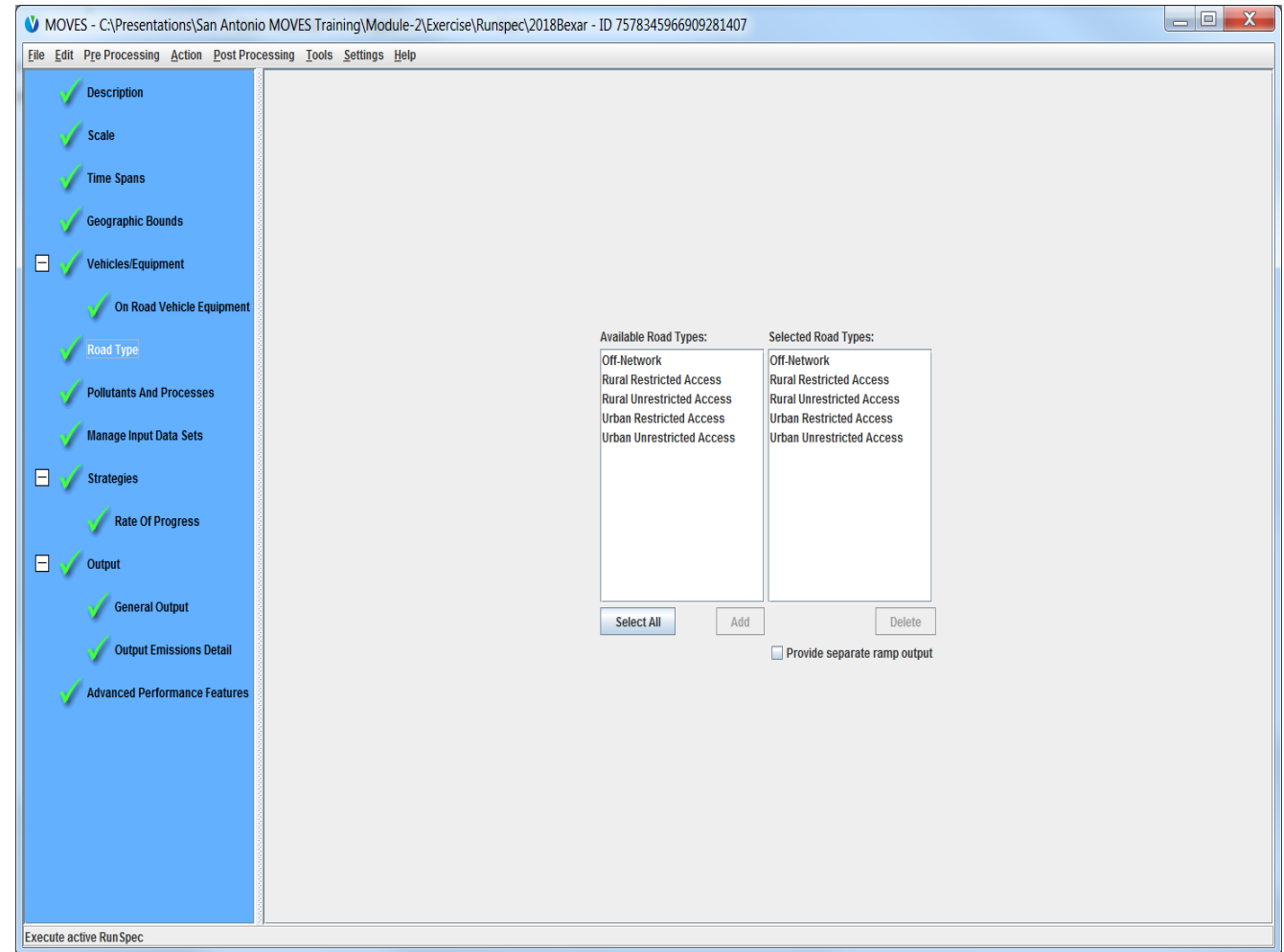
- Freeways/interstate highways
- Toll-ways
- Managed/HOV lanes

Rural & Urban Unrestricted Access

- Arterials
- Collectors
- Locals

Ramps are included as a percent of restricted access

Inclusion of off network will increase the run time



MOVES-Pollutants and Processes

Select

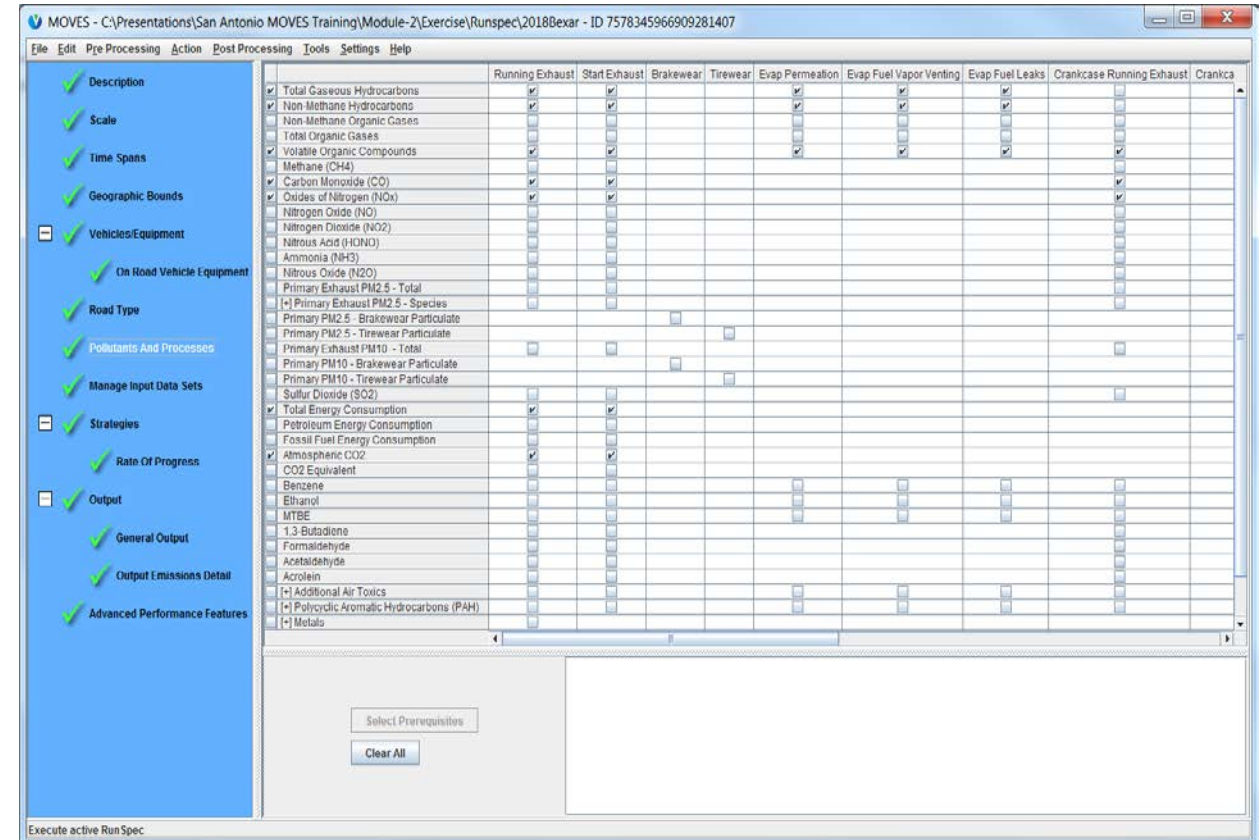
- Oxides of Nitrogen
- Volatile Organic Compounds
- Carbon Monoxide
- Carbon Dioxide

All processes

Refueling is not selected or not considered for conformity

Selecting prerequisite pollutants and processes required

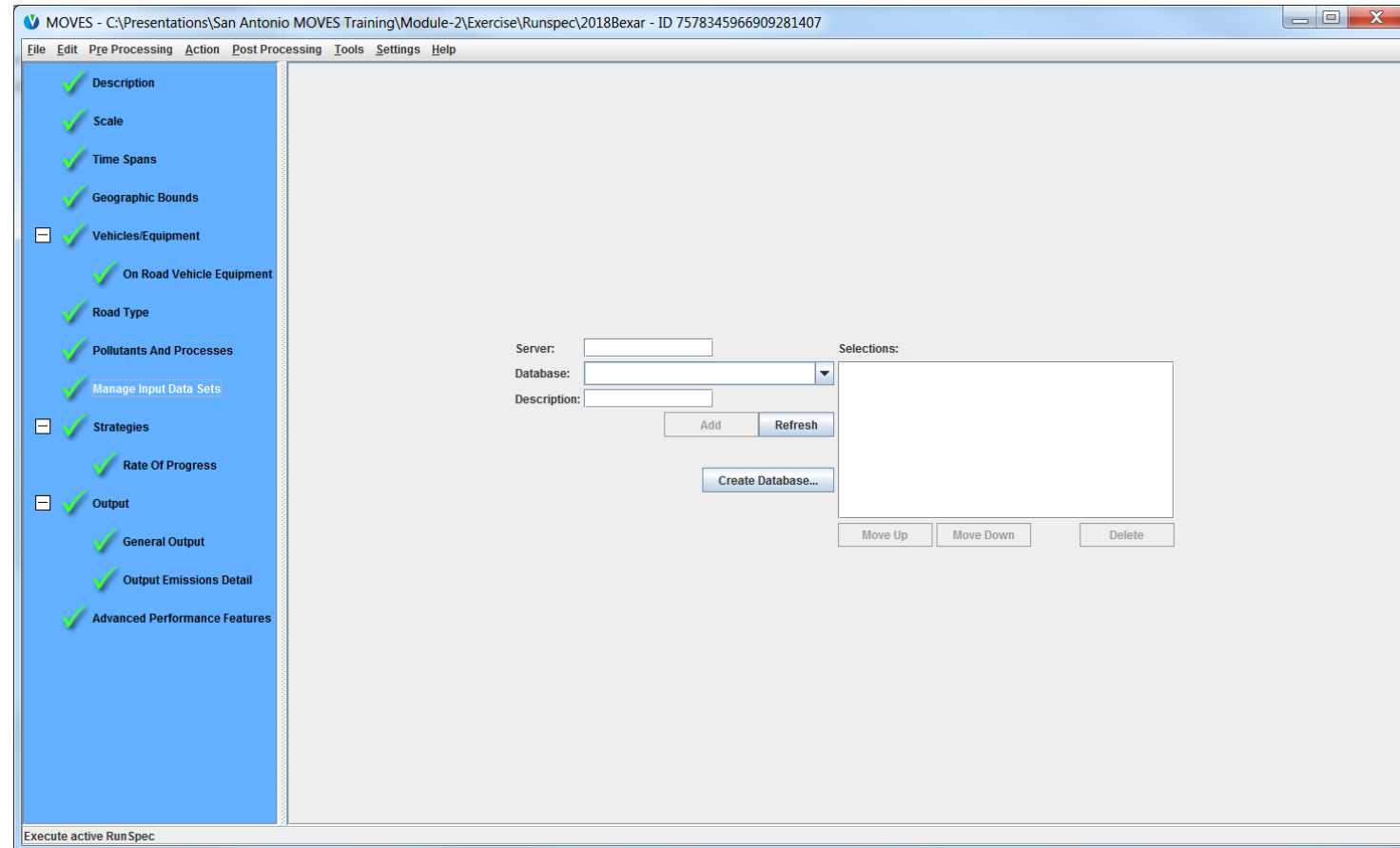
Select only required, can increase the time significantly



MOVES-Manage Input Data Sets

Inputs to
replace
defaults in
addition to
other user
inputs

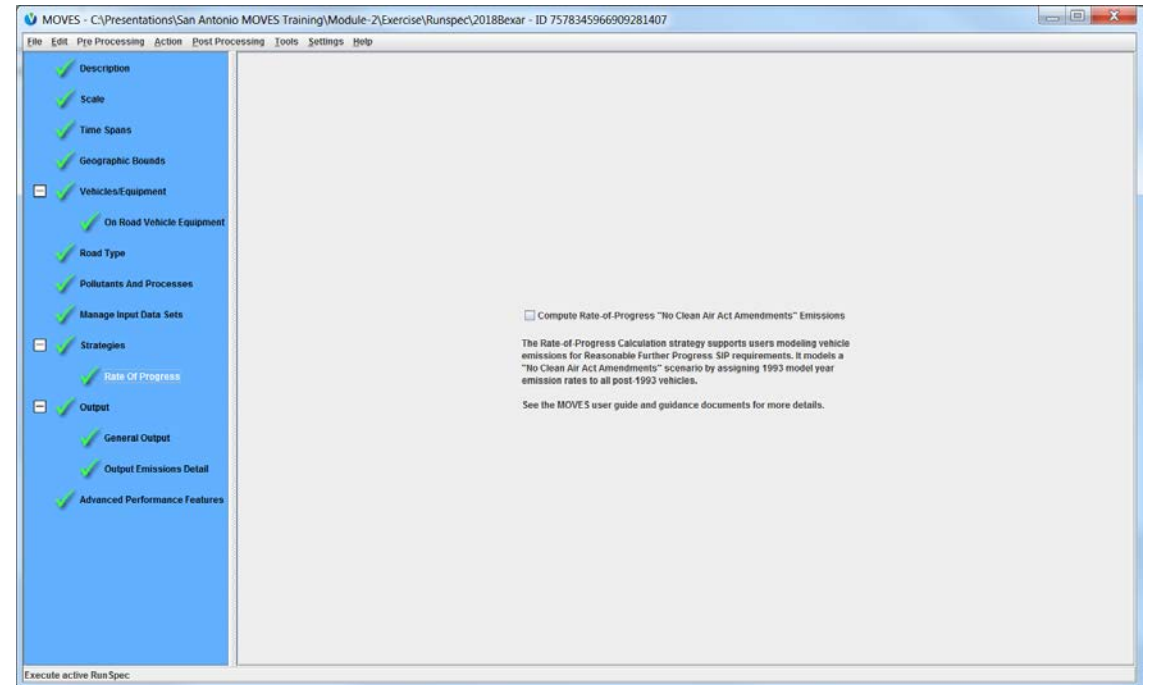
Not
recommended



MOVES- Strategies

Used for Rate of Progress (SIP) run, - estimates emissions as if the 1990 Clean Air Act Amendments was not implemented

Not required for Conformity



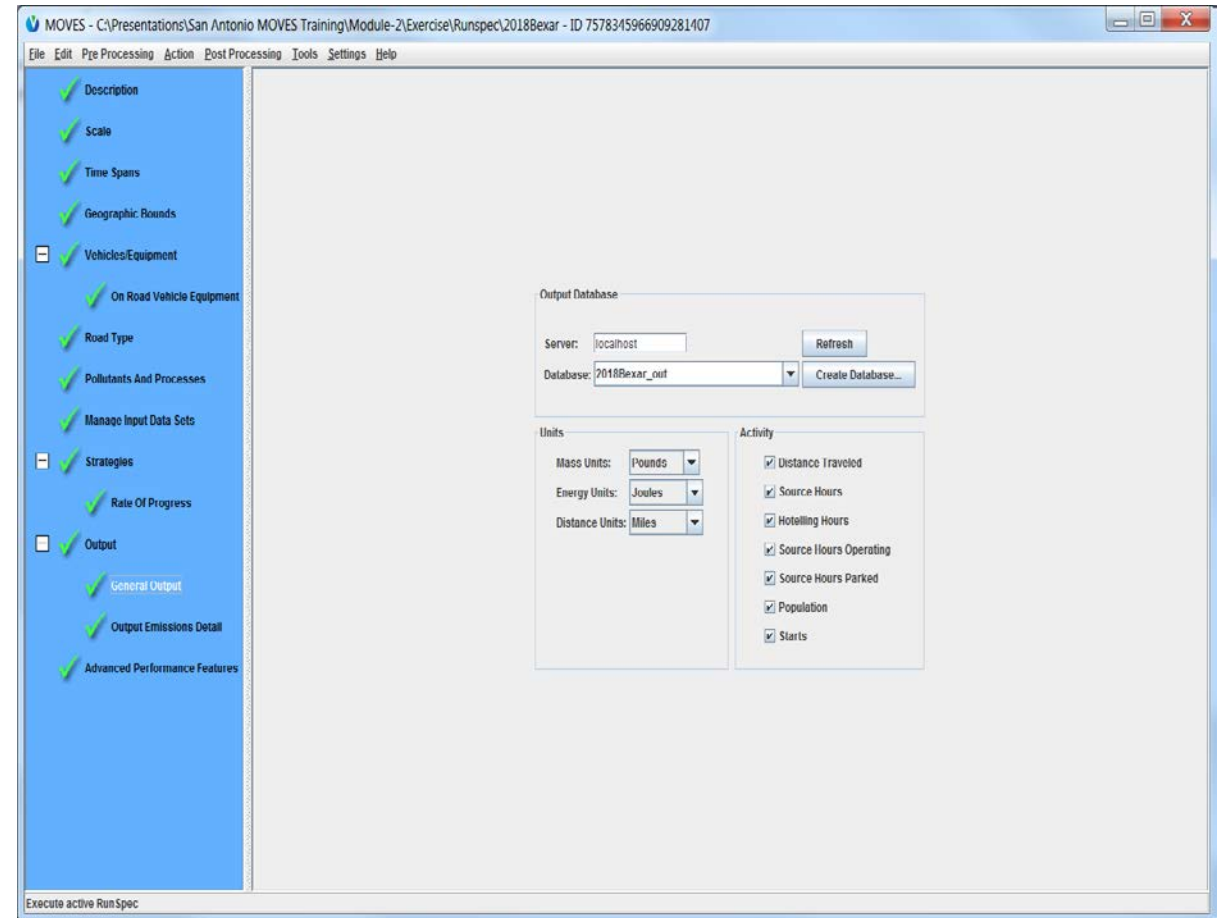
MOVES- Output

Select database name- keep it similar to input but add “_out” (_inv_out)

Activity Outputs- Select all

Units

- Pounds
- Joules
- Miles

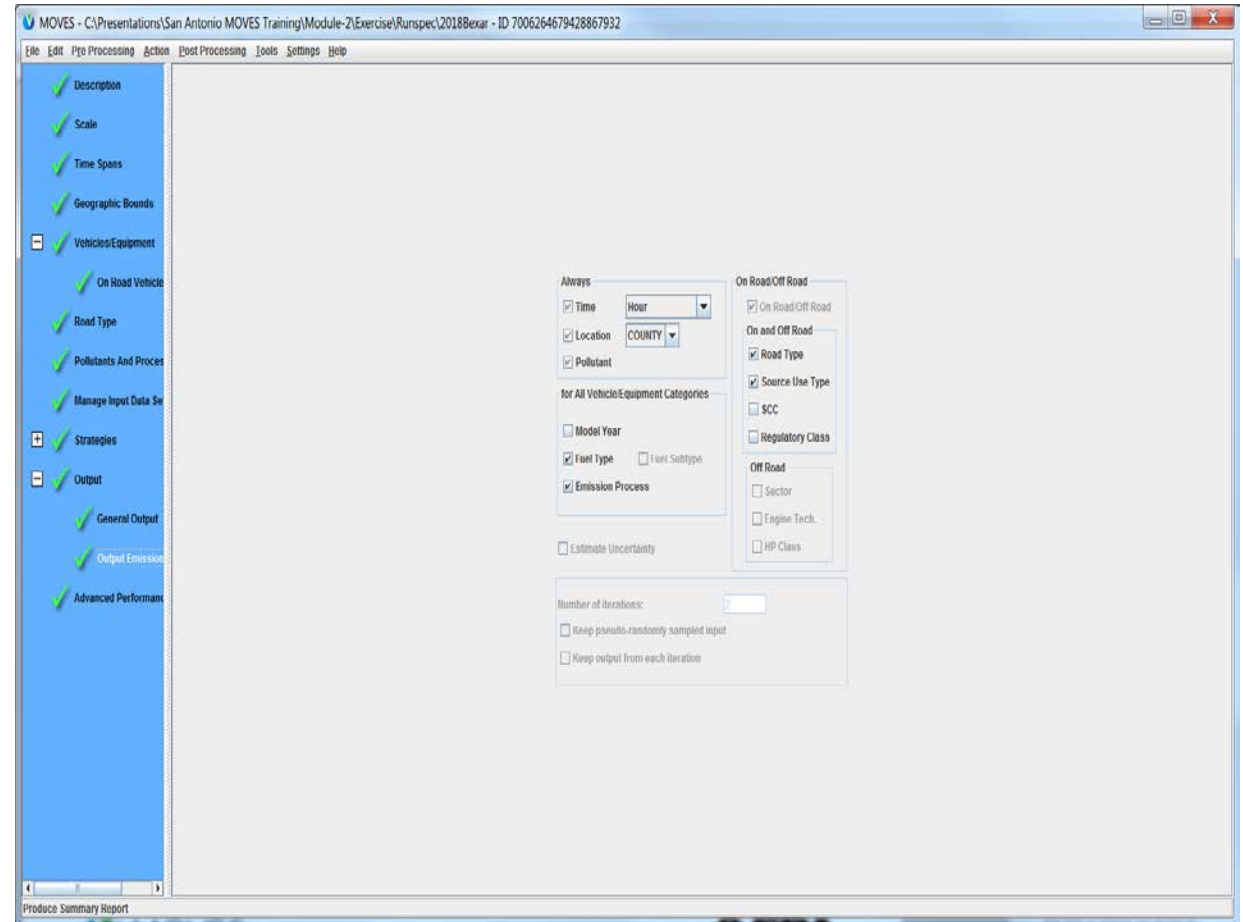


MOVES- Emission Output

Select

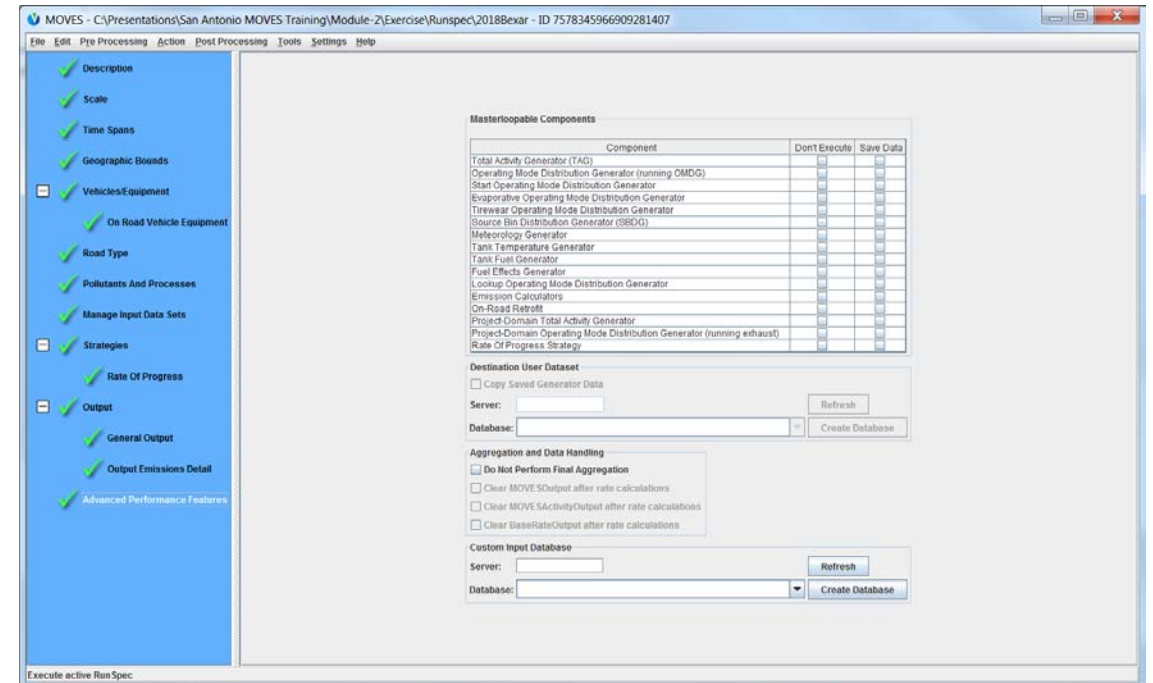
- Hour
- County
- Fueltype
- Emission processes
- Roadtype and Sourceuse type

Detailed input
such as model
year will increase
output size

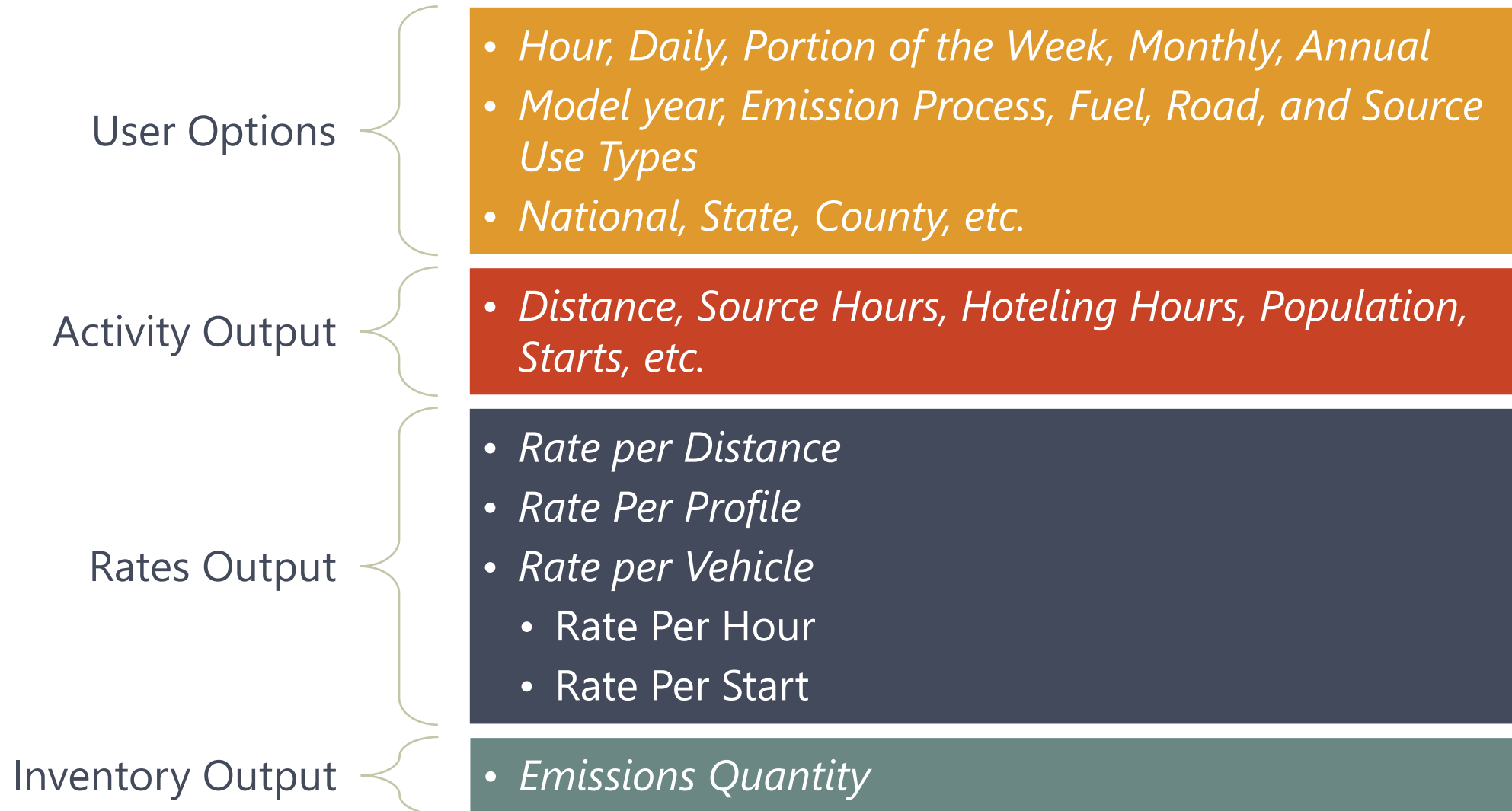


MOVES- Advanced

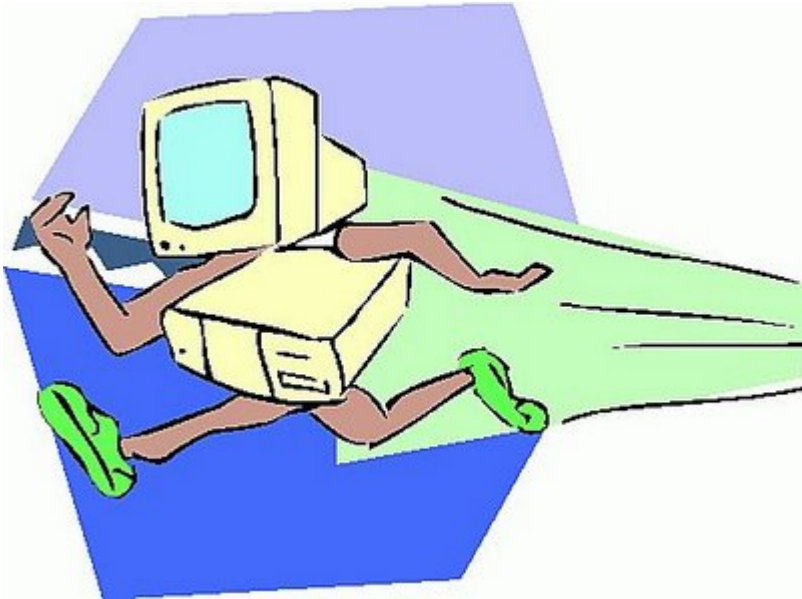
!!! Not used in most cases !!!!



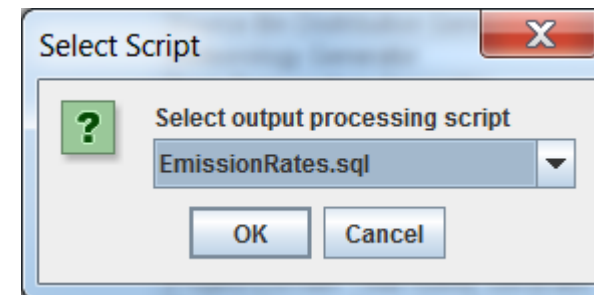
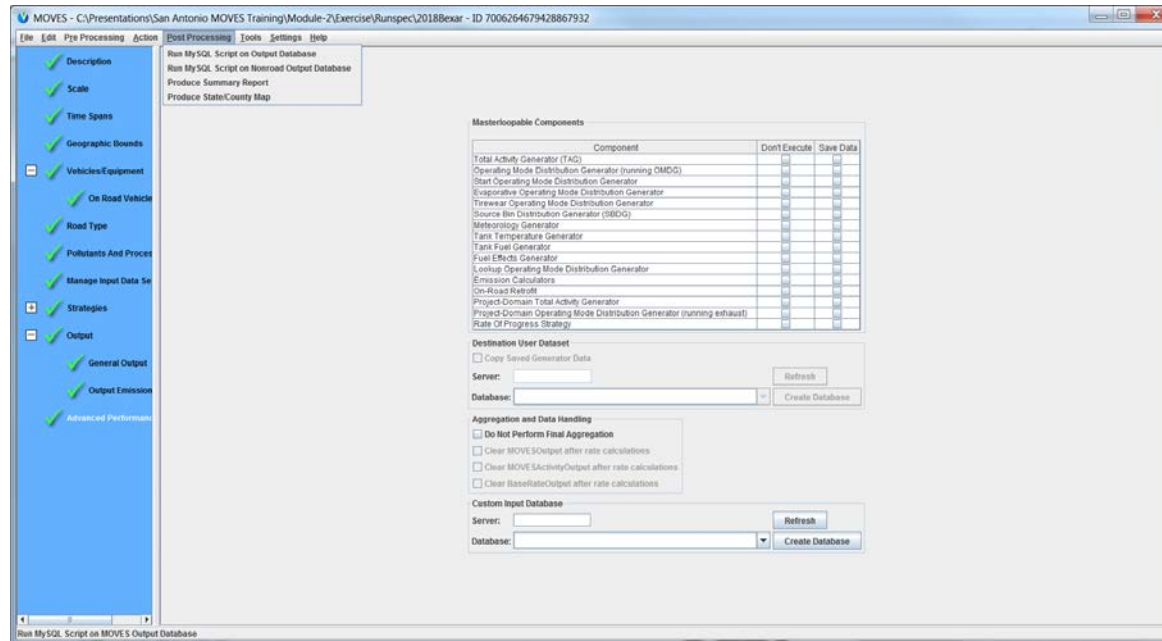
MOVES- Summary



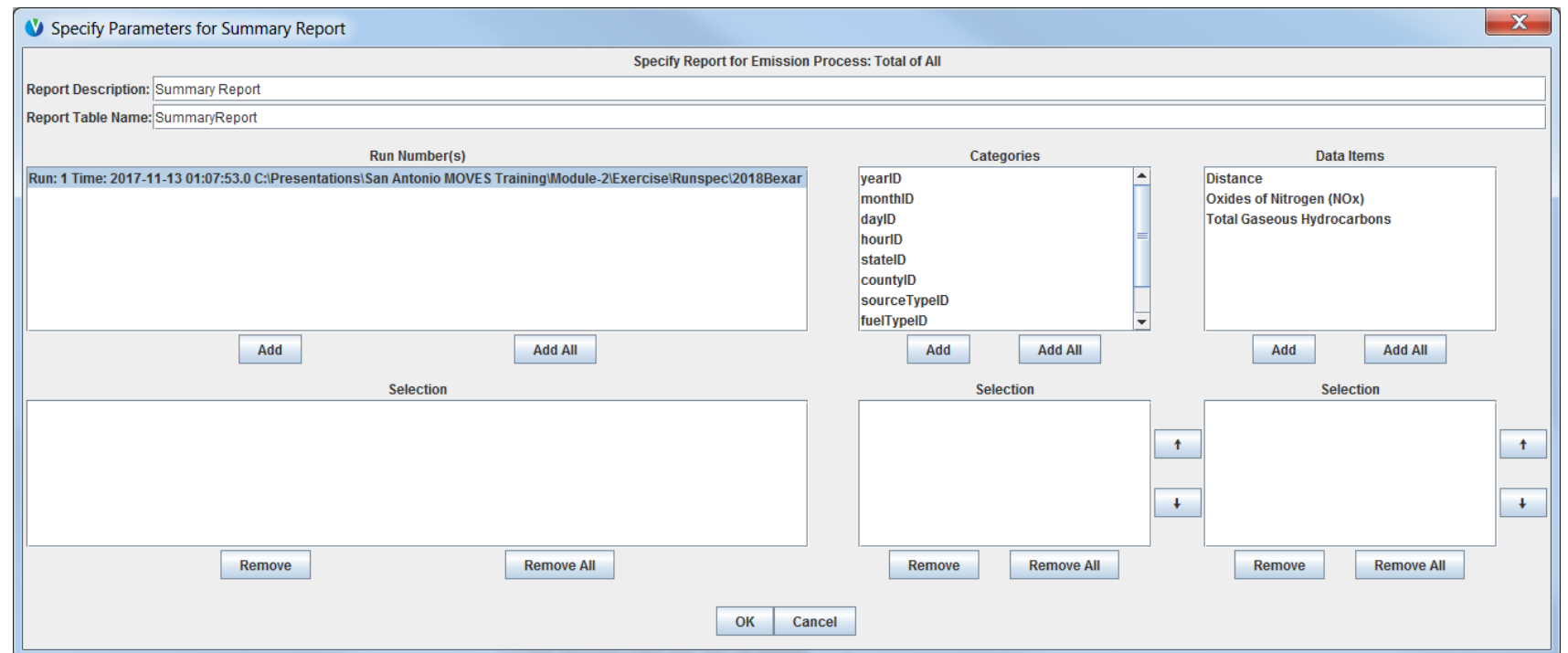
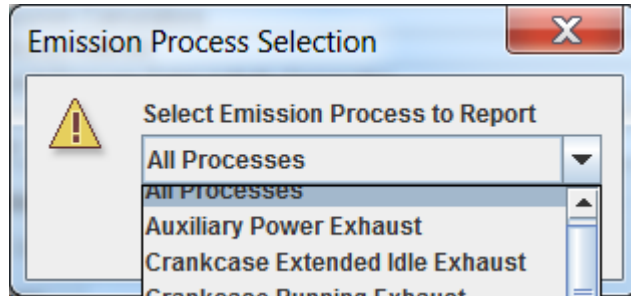
MOVES Execution



MOVES Output Processing



MOVES Output Processing Cont'd



MOVES Output Processing Cont'd

Generate State/County Map

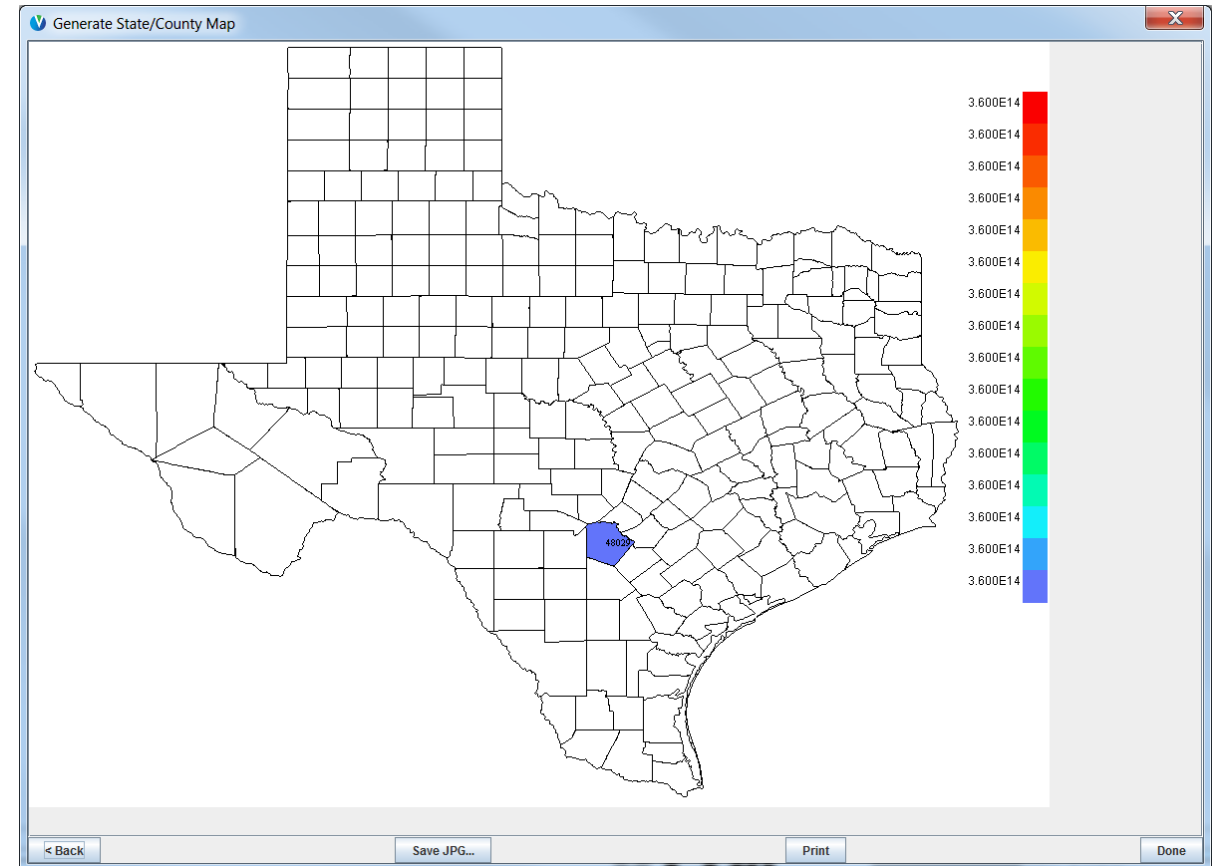
Database: 2018Bexar_out

Table:

State or County FIPS Column:

Data Column:

Cancel Next >



Not so useful if you are running it for one County

MOVES TIPS

Data-Intensive

- *Most Critical Inputs*
- *Inventory Vs. Rate Mode Selection*
- *MYSQL Queries*
- *Changing Default Inputs (Refer EPA Guidance)*

Resource-Intensive

- *Runtime (Depends on Pollutant-Processes, Mode, Output Options, etc.)*
- *Inventory Vs. Rate Mode Selection*
- *Fast Computer & Large Hard-Drive Capacity*
- *Implement Errors Identification Procedures*

***Refer TWG, EPA, & FHWA Guidance Documents ***

